****
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Preparing Activity: KSC

NASA/KSC-27 15 00.00 98 (April 2006)

Superseding
NASA/KSC-16704 (July 2005)

References are NOT in agreement with UMRL dated 01 April 2006

Revised throughout - changes not indicated by CHG tags
****

SECTION TABLE OF CONTENTS

DIVISION 27 - COMMUNICATIONS

SECTION 27 15 00.00 98

COMMUNICATIONS HORIZONTAL CABLING

04/06

PART 1 GENERAL

1.1 REFERENCES
1.2 GENERAL REQUIREMENTS
1.2.1 Scope
1.2.2 Quality Assurance
1.2.3 System Certification and Warranty
1.3 ENVIRONMENTAL REQUIREMENTS
1.4 SUBMITTALS
1.5 SYSTEM DESCRIPTION
1.6 PRELIMINARY DRAWINGS
1.7 AS-BUILT DRAWINGS
1.8 TEST PLAN
1.9 TEST RESULTS

PART 2 PRODUCTS

2.1 HORIZONTAL SEGMENT
2.1.1 100 OHM Unshielded Twisted Pair Cable (UTP) and Screened Twisted Pair Cable (SCTP)
2.1.2 Copper Cable Characteristics
2.1.2.1 Telephone Cable
2.1.2.2 Category 5E Cable
2.1.3 100 OHM Bundled Unshielded Twisted Pair Cable (UTP)
2.1.4 Multimode Optical Fiber Cabling
2.1.4.1 Characteristics
2.1.5 Single mode Optical Fiber Cabling
2.1.5.1 Characteristics
2.1.6 Category 5E Modular Jacks
2.1.7 Optical Fiber Media Adapters
2.1.8 ST - Multimode Fiber Connectors (Field Termination)
2.1.9 MT-RJ Small Form Factor Multimode/Single Mode Optical Fiber Connector (Field Termination)
2.1.10 Modular Patch Cords (Category 5E)
2.1.11 Optical Fiber Patch Cords (Jumpers)
2.1.12 Customer Faceplates (CFP's)

2.1.13 Surface Mount Boxes
2.1.14 Multi-Media Outlet
2.1.15 Remote Distributor
2.1.16 Cable Hangers
2.1.17 Labels
2.1.17.1 Cable Labels
2.1.17.2 Work Station Labels
2.1.17.3 Closet Hardware Labels
2.1.17.4 Rack/Cabinet Labels
2.1.18 Innerduct
2.2 Backbone Segment
2.2.1 Plenum and Riser Rated Optical Fiber Cables
2.2.1.1 Multimode Fiber
2.2.1.2 Single Mode Fiber
2.2.1.3 Physical Characteristics
2.2.1.4 Innerduct
2.2.1.5 Optical Fiber Connectors - SM/MM
2.2.2 Plenum and Riser Rated Copper Cables
2.2.2.1 CMR/CMP Copper Cables
2.2.2.2 ARMM Copper Cables
2.2.2.3 Vault and Riser Closures
2.2.2.4 Vault Closure End Caps
2.2.2.5 Plugs
2.2.2.6 Bushings
2.2.2.7 Lubricants
2.2.2.8 Sealing Kits
2.2.2.9 Clamps
2.2.2.10 Bonding Harness
2.2.2.11 Splicing Modules
2.2.2.12 Splicing Tapes
2.2.2.13 Bonding Connectors
2.2.2.14 Grounding Braid
2.2.2.15 Cable Hangers

PART 3 EXECUTION

3.1 INSTALLATION
3.1.1 Horizontal Segment
3.1.1.1 Raceway and Outlet Box
3.1.1.2 Horizontal Cabling
3.1.1.3 Customer Faceplates (CFP's)
3.1.1.4 Remote Distributors
3.1.2 Backbone Segment
3.1.2.1 Plenum and Riser Rated Optical Fiber Cables
3.1.2.2 Plenum and Riser Rated Copper Cables
3.2 ADDITIONAL MATERIALS (SPARE PARTS)
3.3 LABELING
3.4 CABLE SCHEDULES
3.5 TESTING
3.6 COPPER PAIR TESTING
3.6.1 Backbone Cabling
3.6.2 Horizontal Cabling
3.6.2.1 Category 5E
3.7 OPTICAL FIBER CABLE TESTING
3.7.1 Testing Guidelines
3.7.2 Backbone Cabling
3.7.3 Horizontal Cabling
3.8 FIBER OPTIC CABLE MANUFACTURER TEST DATA
3.8.1 Test Data and Physical Parameters

3.8.1.1 Test Data
3.8.1.2 Physical Parameters
3.8.2 Test Data of Completed Optical Cable
3.8.2.1 Optical Performance Data
3.8.2.2 Temperature Testing Data
3.8.2.3 Mechanical Performance Data
3.8.3 Government Approval

-- End of Section Table of Contents --

****
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Preparing Activity: KSC

NASA/KSC-27 15 00.00 98 (April 2006)

Superseding
NASA/KSC-16704 (July 2005)

References are NOT in agreement with UMRL dated 01 April 2006

Revised throughout - changes not indicated by CHG tags
****

SECTION 27 15 00.00 98

COMMUNICATIONS HORIZONTAL CABLING
04/06

****
NOTE: Delete, revise, or add to the text in this section to cover project requirements. Notes are for designer information and will not appear in the final project specification.

This section covers the minimum requirements for copper and fiber inside cable plant (backbone and horizontal segments), including installation and termination requirements, in support of voice and data telecommunications systems. Accordingly, this section should be tailored carefully to suit project conditions and to meet project requirements.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.
****

PART 1 GENERAL

1.1 REFERENCES

****
NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

BUILDING INDUSTRY CONSULTING SERVICE INTERNATIONAL (BICSI)

TDMM	(1998) 8th Edition, Telecommunications Distribution Methods Manual

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA ANSI/TIA/EIA-568-A	(1995) Commercial Building Telecommunications Cabling Standard
EIA ANSI/TIA/EIA-569-A	(1998) Commercial Building Standard for Telecommunications Pathways and Spaces
EIA ANSI/TIA/EIA-606	(1993) Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
EIA ANSI/TIA/EIA-607	(1994) Commercial Building Grounding and Bonding Requirements for Telecommunications
EIA ANSI/TIA/EIA-TSB-455	(1995) Fiber Optic Test Procedures
EIA ANSI/TIA/EIA-TSB-67	(1995) Transmission Performance Specifications for Field Testing of Unshielded Twisted-Pair Cabling Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2005) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 1479	(2003) Standard for Fire Tests of Through-Penetration Fire Stops
UL 910	(1999) Standard for Safety for Test for Flame Propagation and Smoke Density Values for Electrical and Optical Fiber Cables used in Spaces Transporting Environmental Air

1.2 GENERAL REQUIREMENTS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTALS and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control. Include a columnar list of appropriate products and tests beneath each submittal description.

****

1.2.1 Scope

This section includes the minimum requirements for copper and fiber inside cable plant (backbone and horizontal segments), including installation and termination requirements, in support of voice and data telecommunications systems.

The horizontal portion of the telecommunications cabling system extends from the work area telecommunications outlet/connector to the horizontal cross-connect in the telecommunications closet/room. It consists of the telecommunications outlet/connector, the horizontal cables, optional consolidation point, transition point, and that portion of the cross-connect in the telecommunications closet/room serving the horizontal cable. Each floor of a building shall be served by its own horizontal cabling system.

The backbone portion of the telecommunications cabling system shall provide connectivity between equipment rooms, communications closets, and building entrance facilities. The backbone system shall provide intra-building connectors between floors in multi-story buildings and between equipment rooms/closets, and also provide inter-building connections between buildings on campus or station environments.

1.2.2 Quality Assurance

All methods of construction that are not specifically described or indicated in the Contract Documents shall be subject to the control and approval of the COTR.

Equipment and materials shall be of the quality indicated.

Separation from sources of EMI shall be as specified.

Communication grounding/earthing and bonding shall be in accordance with applicable codes and regulations. Grounding shall meet the requirements of EIA ANSI/TIA/EIA-607, and be observed throughout the entire cabling system. Contractor qualifications shall be in accordance with Section 27 11 19.00 98, "Basic Premise Distribution System Requirements".

1.2.3 System Certification and Warranty

Performance based structured cabling systems such as CAT 5E rated systems, and structured fiber optic cable solutions, shall be provided with a manufacturer backed warranty for both performance characteristics, as well as product reliability. Systems shall be based on a channel-type solution design that consists of an integrated assembly of components from a manufacturer, or manufacturers, that have partnered to warranty the system when assembled using their products. In no case shall any channel be provided that contains a component that is not approved for use in the channel, by the other components manufacturers.

The system warranty shall be based on a single point of contact. The entire warranty including cable, connecting hardware, installation, and performance shall be held by one manufacturer. Other manufacturers of components within the system shall be warranty program partners of the manufacturer holding the warranty.

Warranty shall be industry standards based, with requirements for designers

and installers certified by the manufacturer holding the warranty. Written documentation of the certification of system performance, along with guarantee provided under the warranty, shall be provided by the Contractor at the closeout of the project.

1.3 ENVIRONMENTAL REQUIREMENTS

Connecting hardware shall be rated for operation under ambient conditions of 0 to 60 degrees C, and in the range of 0 to 95 percent relative humidity, non condensing, for the space in which it is to be installed and operate.

1.4 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Scaled FLoor Plans
Front Elevations

Faceplates
Horizontal Patch Panel
Cross-connect Structure

SD-03 Product Data

Manufacturer's catalog data shall be provided for the following items in the horizontal segment:

Horizontal cable (Category 5E and fiber cabling) from telecommunications closet/room to work station

Category 5E Modular Jacks
Optical Fiber Media Adapters and Connectors (of type used)
Faceplates and Jacks
Remote Distributor
Cable Hangers
Innerduct

Manufacturer's catalog data shall be provided for the following items in the backbone segment:

Plenum and Riser Rated Optical Fiber Cables
Riser and Plenum Rated Innerduct
Optical Fiber Connectors - SM/MM
ARMM Copper Cables
CMR/CMP Copper Cables

SD-07 Certificates

Provide copies of signed and dated copies of Completion from BICSI, for the Contractor, Technicians, and Installers, meeting the qualifications required in this specification. Also provide verification of being a manufacturer trained partner or Value-Added Reseller (V.A.R.) for the system installed.

Provide signed and dated Certification and Warranty, certifying that the acceptance testing of the CAT 5E systems are in compliance with the manufacturer's requirements and the warranty is in place.

SD-09 Manufacturer's Field Reports

Test Plan
Test Results

SD-11 Closeout Submittals

As-Built Drawings
Riser Diagram

1.5 SYSTEM DESCRIPTION

Copper horizontal cabling shall be based on 100 ohm 4-pair, unshielded twisted pair (UTP) jacketed cable. Cabling for voice shall be rated CAT 5E and cabling for data systems such as local area networks (LAN), shall be rated as a minimum Category 5E, certified to operate at 100 M/bs, with a bandwidth of 100 MHz. The T568B wiring scheme shall be employed for terminating all pairs under a copper solution. All Category ratings shall

be backward compatible for compliance with earlier Category rating requirements. All components used in a Category 5E solution shall be rated Category 5E. Where necessary to provide greater bandwidth, a horizontal optical fiber cable solution may be specified. Where indicated, the fiber solution shall be based on the small form factor connector type solution and provide fiber optic cable to the customer faceplate (CFP).

1.6 PRELIMINARY DRAWINGS

Prior to beginning work on the project, submit preliminary drawings of the following: (The Contractor shall obtain electronic files of the building floor plan from the Contracting Officer.)

a. Scaled floor plans showing proposed routing of all backbone and horizontal cabling, and proposed communication outlets. Show locations of all remote distributors and communication rooms/closets.

b. Front elevations of each type of typical customer faceplate (CFP).

c. Front elevations of each horizontal patch panel indicating number of each port.

d. Front elevations of a typical cross-connect structure.

1.7 AS-BUILT DRAWINGS

At the completion of the project, submit final record As-Built drawings of the following:

a. Scaled floor plans showing final routings of all backbone and horizontal cabling, and all user outlets (CFP's) and their assigned numbers, in the exact location as they have been installed in each space. Show also all remote distributors and communication rooms/closets.

b. A riser diagram of the complete backbone and horizontal wiring system, indicating diagrammatically all patch panels, cross-connects, and user outlets (CFP's).

Drawings shall be CAD generated on size "F" sheets. Submit reproducible hard copies and electronic copies in ".DXF" or ".DWG" format.

1.8 TEST PLAN

Thirty (30) days prior to beginning any acceptance testing, the Contractor shall submit a comprehensive proposed test plan for review. The following information shall be provided:

a. A complete description of the field test procedures to be performed. Description shall include all steps involved in the testing process, for each type of test to be performed.

b. A comprehensive list of all tests to be performed.

c. A complete description of the test equipment to be used in performing the tests.

d. A sample of the format to be used for test reports.

1.9 TEST RESULTS

At the completion of testing, test data for all tests shall be submitted. Test data shall be presented in an 8-1/2 x 11 format, with one page dedicated to each pair-to-pair test results.

Information to be presented on the page shall include site, building, floor, closet/room, and cable ID. Time and date that the test was performed shall be indicated, and each page shall be signed by the individual performing the test. The type of cable, as well as the cable length for the channel tested, shall also be indicated.

Individual test data shall be presented in tabular format, as well as graphical format where applicable. Also included on the page shall be a pass/fail indication for the respective network tested.

PART 2 PRODUCTS

2.1 HORIZONTAL SEGMENT

2.1.1 100 OHM Unshielded Twisted Pair Cable (UTP) and Screened Twisted Pair Cable (SCTP)

Cable shall be 100 ohm 4-pair, Category 5E for telephone, and Category 5E, or higher cable for data (LAN) applications, and be appropriate for the environment in which it is installed. Cable shall be labeled and third party "Verified" CAT 5E cable.

Gray cable shall be provided for all cables terminated to 110 system blocks in the telecommunications closet/room that are designated for analog or digital telephone services. White cable shall be provided for all cables terminated to patch panels in the telecommunications closet/room that are designated for data services. Yellow cable shall be provided for all cables terminated to 110 system blocks in the telecommunications closet/room that are designated for service to fire panels, security panels, emergency phones, elevator phones.

2.1.2 Copper Cable Characteristics

2.1.2.1 Telephone Cable

Horizontal telephone cable shall be rated CAT 5E.

a. Physical Description:

See paragraph entitled, "Category 5E Cable," of this section.

b. Electrical Characteristics:

See paragraph entitled, "Category 5E Cable," of this section.

2.1.2.2 Category 5E Cable

Horizontal CAT 5E cable shall meet the following criteria:

a..Physical Description:

Conductor: UTP solid copper, 100 ohm, 24 AWG, 4 pairs, each

twisted with a different lay length, to minimize crosstalk. Four pair (4), 22 AWG cables that met the transmission requirements of this section may also be used. Each pair shall have a different twist ratio per foot, ranging from 12 to 24 twisted per 30.48 cm (1 foot).

Insulation: Dual polyethylene insulated for non-plenum, or Teflon insulated for plenum, cables tightly twisted into pairs for either type of cable.

Shielding: None.

Jacket: Fire retardant polyethylene for non-plenum and low smoke PVC for plenum cables.

b. Electrical Characteristics:

Attenuation: Worst case qualified cable attenuation performance: 100 MHZ - 22 dB.

Near End Crosstalk (NEXT) Loss: Worst case qualified cable NEXT Loss performance: 100 MHZ - 35.3 dB.

Power Sum Near-End Crosstalk (PSNEXT) Loss: Worst case qualified cable PSNEXT Loss performance: 100 MHZ - 32.3 dB.

Equal Level Far-End Crosstalk (ELFEXT): Worst case qualified cable ELFEXT performance: 100 MHZ - 23.8 dB.

Power Sum Equal Level Far-End Crosstalk (PSELFEXT): Worst case qualified cable PSELFEXT performance: 100 MHZ - 20.8 dB.

Return Loss: Worst case qualified cable Return Loss performance: 100 MHZ - 20.1 dB.

Propagation Delay (EIA ANSI/TIA/EIA-568-A): Worst case qualified cable Propagation Delay performance: 100 MHZ - 538 ns.

Delay Skew (EIA ANSI/TIA/EIA-568-A): Qualified cables shall exhibit worst case Delay Skew less than: 100 MHZ - 45 ns.

2.1.3 100 OHM Bundled Unshielded Twisted Pair Cable (UTP)

Cable shall be in groupings of 4-pair units and shall meet the transmission performance and color code specifications as defined in EIA ANSI/TIA/EIA-568-A. Cable shall be power sum NEXT tested where any disturbed pair within the bundled cable shall be 3 dB better than the specified pair-to-pair NEXT loss of a single 4-pair cable of the same Category. Cable shall be appropriate for the environment in which it is installed, consist of 100 pair cables, and be Category 5E or higher cable.

2.1.4 Multimode Optical Fiber Cabling

Cable shall be a minimum of two strands of 62.5/125 or 50/125um multimode optical fiber for horizontal cabling and be appropriate for the environment in which is it installed. Multimode optical fiber cables shall meet all of the requirements delineated within the specifications of EIA ANSI/TIA/EIA-568-A. Cable shall be constructed of tight buffered fiber (900 micrometer buffer), with Aramid yarn reinforcement surrounded by an

outer jacket. Cable shall be configured as a two-strand cable in single jacket, or bonded Simplex cables forming a zip cord construction.

2.1.4.1 Characteristics

Horizontal multimode fiber optic cable shall meet the following criteria:

	Multimode (50/125 um)	Multimode (62.5/125 um)
Wavelength:	(850 nm/1300 nm)	(850 nm/1300 nm)
Maximum Attenuation Loss:	3.5/2.0 dB/km	3.5/1.2 dB/km
Typical Attenuation Loss:	3.0/1.0 dB/km	3.0/1.0 dB/km
Bandwidth MHz/km:	400/400	200/500
Transmission Distance:	550m/550m	275m/550m

2.1.5 Single mode Optical Fiber Cabling

Cable shall be appropriate for the environment in which it is installed. Single mode fiber optical fiber cables shall meet all of the physical requirements delineated for multimode cable.

2.1.5.1 Characteristics

Horizontal single mode fiber optic cable shall meet the following criteria:

	Single-Mode
Wavelength:	(1310 nm/1550 nm)
Maximum Attenuation Loss:	0.50/0.50 dB/km
Typical Attenuation Loss:	0.40/0.30 dB/km
Transmission Distance:	5,000m

2.1.6 Category 5E Modular Jacks

Jacks shall be available in black, office white, gray, and electrical ivory, be 8-position/8-conductor with 110 IDC termination, have both straight and angled mounting, and provide universal application/multi-vendor support.

Units shall support T568A or T568B standards wiring options and allow for front or rear jack insertion into the faceplate. Termination shall be made using standard termination tools.

Jacks shall be constructed of high impact, flame-retardant thermoplastic, shall be able to except 100 ohm 22-24 AWG copper cable, and be verified for TIA/EIA Category 5E electrical performance.

Jacks shall meet the following requirements (NEXT Loss and FEXT tested in both Differential and Common Mode):

PARAMETERS	PERFORMANCE @ 100 MHZ
NEXT Loss	43.0 dB
FEXT	35.1 dB
Insertion Loss (Attenuation)	.4 dB
Return Loss	20 dB

2.1.7 Optical Fiber Media Adapters

Adapters shall be available in office white or electrical ivory, gray and black, as well as all TIA 606 colors. They shall be flush mounted, flat or angled design, accommodate a minimum of two SC, ST or MT-RJ style adapters, include options for both multimode and single mode connectors, and be removable from the front with the faceplate left mounted in place, and allow for the jack to pass through the faceplate without re-termination. Adapters shall be equipped with dust covers for unused ports and be made of high impact flame-retardant thermoplastic.

2.1.8 ST - Multimode Fiber Connectors (Field Termination)

Connectors shall have a quick field termination process, which does not require power. They shall have a termination process, which incorporates use of a reliable anaerobic adhesive, which has a high resistance to environmental extremes, have a buffered fiber version consisting of 2 parts (connector housing and boot), and have a jacketed fiber version consisting of 3 parts (connector housing, crimp sleeve, and boot). The jacketed fiber version shall be available with either beige or a black boot (to facilitate fiber identification).

Connectors shall have a metal coupling nut to assure optimum durability, have a radial-ramped coupling nut, which facilitates mating/de-mating, and utilize a precision zirconia ceramic ferrule. Unit shall have a typical Insertion Loss = 0.50 dB via manual polish method or 0.2 dB using an automatic fiber polisher, and be EIA ANSI/TIA/EIA-568-A compliant.

2.1.9 MT-RJ Small Form Factor Multimode/Single Mode Optical Fiber Connector (Field Termination)

Connector shall house two fibers inside a single connector ferrule, allowing transmission and receiving to a single connector. Connector shall use MT-RJ latching mechanism and copper standard phone jacks.

The connector shall be suitable for use on either single-mode or multimode applications, and shall meet the requirements of EIA ANSI/TIA/EIA-568-A.

The connectors shall comply with the following performance characteristics:

PARAMETER	MULTIMODE	SINGLE-MODE
Insertion Loss (typical)	0.2 dB	0.2 dB
Insertion Loss (maximum)	<0.50 dB	<0.75 dB

PARAMETER	MULTIMODE	SINGLE-MODE
Durability (500 cycles)	≤0.2 dB change	≤0.2 dB change
Reflectance	-20 dB minimum	-50 dB typical

2.1.10 Modular Patch Cords (Category 5E)

Cords shall be round, and consist of eight insulated 24 AWG, stranded copper conductors, arranged in four color-coded twisted-pairs within a flame-retardant jacket. Cords shall be equipped with modular 8-position plugs on both ends, wired straight through with standards compliant wiring. Modular plugs shall exceed FCC CFR 47, part 68, subpart F, and IEC 60603-7 specifications, and have 50 microns minimum of gold plating over nickel contacts. Plugs shall be resistant to corrosion from humidity, extreme temperatures and airborne contaminants.

Cords shall utilize cable that exhibits power sum NEXT performance, be available in several colors with or without color strain relief boots providing snagless design, and must meet the flex test requirements of 1000 cycles with boots and 100 cycles without boots. Cords shall be available in any custom length and standard lengths of meters (3, 5, 7, 10, 15, 20, and 25 meters).

Input impedance without averaging shall be 100 ohm +/-15% from 1 to 100 MHz. Cords shall be 100% transmission tested for performance up to 100 MHz. Manufacturer shall guarantee cords are compatible with Category 5E links. Utilize cable that is verified for TIA/EIA proposed Category 5E electrical performance.

2.1.11 Optical Fiber Patch Cords (Jumpers)

Cords shall be available in standard lengths of 1, 3, and 5 meters, custom lengths shall also be available, and shall meet or exceed standards as defined in EIA ANSI/TIA/EIA-568-A. Utilize duplex optical fiber cable that is 62.5/125 or 50/125 micron multimode, OFNR riser grade, and meets the requirements of UL 1666. Attenuation shall not exceed 3.5 dB/km @ 850 nm wavelength or 1.0 dB/km @ 1300 nm.

Cords shall have a cable jacket color for 62.5/125 in gray and 50/125 in orange, and be equipped with ST, or MT-RJ in accordance with EIA ANSI/TIA/EIA-568-A. (Include a ceramic ferrule.) Have ST connectors supplied with a metal coupling nut.

Cords shall have terminated connectors exhibit a maximum Insertion Loss of 0.75 dB with an average of 0.40 dB when tested at either 850 nm or 1300 nm wavelengths for 62.5/125 um, and have terminated connectors exhibit a maximum Insertion Loss of 0.75 dB with an average of 0.50 dB when tested at either 850 nm or 1300 nm wavelengths for 50/125 um. Minimum return loss shall be 20 dB (25 dB typical) at both 850 nm and 1300 nm.

2.1.12 Customer Faceplates (CFP's)

Faceplates shall be applicable to both fiber and copper applications, have designation labels for circuit identification together with a clear plastic cover, and be available in single-gang and double-gang configurations. Single-gang plates shall accommodate up to 6 ports. As a minimum, the standard colors of black, office white, gray, and electrical ivory shall be

available, along with modular furniture adapters. Plates shall also be available in stainless steel. Module inserts shall be front-loaded and be angled down in the faceplate. Surface mount boxes and standoff rings shall be available for both single and double gang faceplates. Boxes shall provide for one (1) meter of cable storage.

2.1.13 Surface Mount Boxes

Boxes shall be available in 2-, or 4-port versions, have built-in cable management for both optical fiber and copper applications, and accept modular Category 5E, as well as all media adapters.

Available colors shall be black, office white, gray, and electrical ivory. At least three sides shall be provided with breakouts and an opening in the base for cable or raceway entry, have a designation area for printed or adhesive labels for circuit identification with clear plastic protector, and have color-coded snap-in icons for circuit identification.

2-port box shall not exceed 69mm2.7 inches width, 53mm2.1 inch length, and 38mm1.5 inches height. 4-port box shall not exceed 120mm4.7 inches width, 97mm3.8 inches length, and 38mm1.5 inches height.

2.1.14 Multi-Media Outlet

Outlet shall be surface mounted, provide either [4] or [8] ports, and be available in black, office white, gray and electrical ivory.

Outlet shall be capable of accepting ST, and MT-RJ type connectors for optical fiber; 8-position/8-conductor modular jacks for 100 ohm UTP/ScTP cable; and other multi-media adapters. It shall be capable of integrating UTP/ScTP fiber, and connectivity outlets, and be capable of accommodating up to 12 ports of mixed media (UTPScTP, fiber, or coax outlets simultaneously) or up to 24 MT-RJ optical fiber ports.

Outlets shall have an under cover labeling system compliant with EIA ANSI/TIA/EIA-606 administrative standards, have rear cable access and at least three sides with breakouts for cable/raceway entry with strain relief points, and have storage capacity for at least 1 meter3.28 ft. of fiber and 305mm12 inches for UTP slack storage, while maintaining minimum bend radius requirements. Information outlets shall be allowed to pass through openings before or after termination, and device shall have a low-profile design.

2.1.15 Remote Distributor

Unit shall consist of an aluminum enclosure suitable for mounting within a 0.6 m x 1.2 m2' x 4' access ceiling grid. Enclosure shall be provided with a swing down, fully hinged access door, with door supports that brace the door at 90 degrees to the ceiling for access. Entire unit shall be rated for plenum or non plenum use.

An equipment mounting plate shall be attached to the inside of the enclosure access door. Equipment mounting plate shall be compatible with all patch panels and 110 punch panels, for copper Category 3 or 5E cable, as well as fiber or coax terminations and splices.

The unit shall accommodate [24], [48], [72], 8-pin modular jacks and a total of 384 copper pair in/384 copper pair out. Door load capacity shall be equal to 9 kg10 pounds with a total overall enclosure capacity of 32 kg

70 pounds.

Remote distributor shall be constructed in compliance with EIA ANSI/TIA/EIA-568-A.

2.1.16 Cable Hangers

Cable hangers should be flexible cable wrap type, or rigid steel j-hooks. Cable wrap type should be adjustable to 102mm4 inches to 152mm6 inches diameter bundle. J-hooks shall be rated for use on Category 5E copper cables and fiber optic cables as well. Cable hangers shall support a minimum static load of 23 kg50 pounds. Provide units complete with all required mounting hardware.

2.1.17 Labels

All labels shall be in accordance with EIA ANSI/TIA/EIA-606. Labels shall not be handwritten but shall be made using a device which produces typewritten print on a permanent marking to secure around cable or on equipment in a permanent manner.

2.1.17.1 Cable Labels

Labels shall be laser printed labels made from a low-profile, heat resistant polyester. Labels on plenum rated cable shall be made of low-smoke and flame material.

2.1.17.2 Work Station Labels

Work station labels shall be laser printed on laser printable, clear vinyl material with aggressive adhesive for textured plastics.

2.1.17.3 Closet Hardware Labels

Closet hardware labels for 110 blocks and patch panels shall be laser printed on laser printable, clear vinyl material with aggressive adhesive for textured plastics.

2.1.17.4 Rack/Cabinet Labels

Rack/cabinet labels for equipment racks and cabinets shall be laser printed on laser printable, clear vinyl material with aggressive adhesive for textured plastics.

2.1.18 Innerduct

Innerduct shall be constructed of a PVC plenum rated plastic. It shall be in diameter as called for on the drawings, be orange in color, and shall have a maximum flame rating of UL 910.

2.2 Backbone Segment

2.2.1 Plenum and Riser Rated Optical Fiber Cables

2.2.1.1 Multimode Fiber

Multimode fiber cables shall be graded-index optical fiber waveguide with nominal 62.5/125um-core/cladding diameter. The primary coating shall be UV cured acrylate buffer material, with a diameter of 900 micrometers. Each

cabled fiber shall meet the following graded performance criteria. The measurements shall be performed at 23 degrees C +/- 5 degrees.

a. Maximum attenuation dB/Km @ 850/1300 nm: 3.25/1.0.

b. Bandwidth 200 MHz-km @ 850nm.

c. Bandwidth 800 MHz-km @ 1300nm.

2.2.1.2 Single Mode Fiber

Single mode fiber optic cables shall be rated Class IVa dispersion - unshifted single mode optical fibers. Primary coating shall be UV cured acrylate buffer material, with a diameter of 250 micrometers.

The zero dispersion wavelength shall be between 1300nm and 1324nm. The maximum value of the dispersion slope shall be no greater than 0.093 ps/km-nm2.

The nominal mode field diameter shall be 8.7 um to 10.0 um with a tolerance of +/- 0.5 um at 1300nm.

Transmission Characteristics:

a. Maximum attenuation dB/Km @ 1310/1550nm: 1.0/1.0.

b. The cutoff wavelength shall be <1279nm.

2.2.1.3 Physical Characteristics

Multimode and single mode plenum and riser rated fiber optic cables shall have the following physical characteristics:

a. 900 um tight buffer.
b. 2.0 mm sub-unit diameter.
c. OFNR/OFN Flame Rated.
d. Suitable for indoor installations.
e. Strength members shall be FGE/Aramid yarn with extruded PVC sub-cable jacket.
f. Secondary thermoplastic type buffer over each fiber.
g. Suitable for underground or above ground conduits.
h. Shall have individual fiber tube colors per EIA ANSI/TIA/EIA-606 and overall orange jacket.
i. Provide stiff central member with cables stranded around center.
j. Provide ripcord for overall jacket.
k. Suitable for -40 degrees to 80 degrees C.
l. Suitable for lashing.
m. Must be UV rated for exterior installation.

2.2.1.4 Innerduct

Innerduct shall be constructed of a PVC riser rated or plenum rated plastic as required. It shall be 1" or 1-1/4" in diameter as called for on the drawings, be orange in color, and shall have a maximum flame rating of UL 910.

2.2.1.5 Optical Fiber Connectors - SM/MM

Fiber optic connectors shall be duplex 568SC connectors. Multimode

connectors shall be orange colored, single mode connectors shall be yellow colored. The connector shall have an optical axial pull strength of 2.2 N at 0 degree angle and an optical off axial pull strength of 2.2 N at a 90 degree angle, with a maximum 0.5 dB increase in attenuation for both tests.

The maximum optical attenuation per each mated field installed 568SC connector pair shall not exceed 0.5 dB. The total optical attenuation through the cross-connect from any terminated optical fiber to any other terminated fiber shall not exceed 1.0 dB. Each connector shall have a return loss greater than or equal to 20 dB for multimode fiber and greater than or equal to 26 dB for single mode fiber. The connectors shall sustain a minimum of 500 mating cycles without degrading this performance.

2.2.2 Plenum and Riser Rated Copper Cables

2.2.2.1 CMR/CMP Copper Cables

Backbone UTP cables shall be plenum rated and consist of 24 AWG, groups of 50/100 pair thermoplastic insulated copper conductors. The 50/100 pair groups shall be bound together and covered by a protective sheath consisting of an overall thermoplastic jacket, an underlying metallic shield, and one layer of dielectric material applied over the core.

The resistance of any conductor, shall not exceed 9.38 ohms per 100m at 20 degrees C. The resistance unbalance between the two conductors of any pair shall not exceed 5%. The mutual capacitance of any pair shall not exceed 6.6 nF per 100m. The capacitance unbalance to ground at 1 kHz of any pair shall not exceed 330 pF per 100m. The characteristic impedance shall be 100 ohm +/- 15% from 1 kHz to 16 MHz. The attenuation shall meet the requirements of the horizontal cable specified in Section 27 15 00.00 98. The insulation between each conductor and the core shield shall be capable of withstanding a minimum dc potential of 5 kV for 3 seconds. The propagation delay of any pair at 10 MHz should not exceed 5.7 ns/m.

The Power Sum NEXT loss shall meet the following:

FREQUENCY (MHz)	NEXT LOSS (dB)
0.150	53
0.772	43
1.0	41
4.0	32
8.0	27
10.0	26
16.0	23

2.2.2.2 ARMM Copper Cables

Designation represents the following:

A - PIC riser
R - Expanded polyethylene-polychloride
M - 24 GA
M - Alvyn sheath, aluminum shield

ARMM copper cables shall be of size indicated on the drawings, shall consist of a core of 24 AWG solid annealed copper conductors, and color coded in accordance with telephone industry standards. The nominal resistance of any conductor shall not exceed 27.3 ohms per 305 m1000 feet

at 20 degrees C. The mutual capacitance of any pair shall not exceed 15.7 nF per 305 m1000 feet at 1 kHz, and the maximum attenuation at 1.0 MHz shall not exceed 6.8 dB per 305 m1000 feet. Conductors shall be twisted to form pairs. Cable having more than 25 pairs shall be assembled in units, each individually identified by color coded unit binders. The core shall be covered with a plastic tape, and the core and tape shall be overlaid with a corrugated shield applied longitudinally with overlap using the following materials:

a. .203 mm.008 inch coated aluminum.

b. .127 mm.005 inch copper.

c. Shall be bonded to outer jacket to form an ALVYN sheath.

The outer jacket shall consist of a fire retardant sheath that meets NFPA 70 low flame requirements, and cable shall be suitable, listed and marked for use in a riser application (CMR). Manufacturers cable code, pair size, manufacturing plant location, month and year or manufacture shall be marked on cable every 0.6 m2'-0".

2.2.2.3 Vault and Riser Closures

Vault and riser closures shall consist of a black solid or split PVC sleeve as indicated on the drawings, shall have a minimum inside diameter of 120mm 5", and shall have a minimum inside length of 660mm26". Actual sizes shall be indicated on the drawings. Otherwise, closure to be sized to accommodate the maximum number of cable pairs to be spliced and the type of connector to be used for splicing. Closure shall be flame retardant, re-enterable, and when assembled with properly sized end caps, bushing, plugs and clamps, the closure shall be air and water tight.

2.2.2.4 Vault Closure End Caps

At MDF and BDF locations, multiple end caps shall be sized precisely to fit the diameter of the tip cables entering the closure. The number of openings in the multiple end caps shall be determined by dividing the number pairs in the feed cable by 100 and doubling that number. (ie. 1200 pair cable would have 24 openings for tip cables.) Collared end cap opening can be up to 6.35mm1/4" larger than the feed cable diameter. Actual end cap to be provided shall be based on the diameter of the feed cable to be spliced.

2.2.2.5 Plugs

Use tapered or collared plugs as required to fill extra opening in end caps and seal if inside diameter of hole is less than 6.35mm.25".

2.2.2.6 Bushings

Use rubber or variable bushings as required to reduce standard opening in end caps to accommodate custom diameters and seal inside diameter if hole is less than 6.35mm.25".

2.2.2.7 Lubricants

Lubricant shall evaporate and shall not damage closure elements in any way. Completely remove excess lubricant around closure and clean from affected areas.

2.2.2.8 Sealing Kits

Sealing kits shall consist of a urethane adhesive designed for sealing split vault sleeves and split end caps.

2.2.2.9 Clamps

Provide sleeve and collared clamps as required to complete work. Clamps shall be adjustable so as to ensure proper fit.

2.2.2.10 Bonding Harness

Bonding harnesses shall be used to ground the shields of the spliced cables. Bonding harness shall be copper 14 AWG and sized according to closure.

2.2.2.11 Splicing Modules

All splicing modules shall have an integrated encapsulate in all environments. (ISP and OSP.) Crimping process shall strip the installation from the wire and trim the excess wire. The module shall create a gas tight connection and all modules shall have test entry ports on the front side of the module. Straight splicing modules shall have a yellow cover and body top and the base and body bottom shall be dark gold. Pluggable/bridge splicing modules shall have a transparent cover, the body top and bottom shall be blue and the insulator shall be red.

2.2.2.12 Splicing Tapes

Splicing tapes shall be an all weather, vinyl plastic material, they shall resist water, acids, and alkalis, be flame retardant, and shall not be affected by sunlight. Tapes shall release smoothly in zero weather and will not ooze adhesive in hot climates.

2.2.2.13 Bonding Connectors

Bonding connectors shall consist of a base and upper member, two securing nuts and a plastic shoe to aid connector installation and protect the conductors. Base and upper members shall be made of tin plated tempered brass, slightly curved so as to exert a continuous spring form on sheath and shield after clamping.

2.2.2.14 Grounding Braid

Grounding braid shall be a flat tin plated copper braid conductor, and shall have eyelets at regular intervals. Eyelets shall fit shield connector studs up to 6mm1/4" in diameter.

2.2.2.15 Cable Hangers

Cable hangers shall be flexible cable wrap type or rigid steel j-hooks. Cable wrap type shall be adjustable to 102mm4" diameter bundle. J-hooks shall be rated for use on Category 5E copper cables, and fiber optic cables. Cable hangers shall support a minimum static load of 23 kg50 pounds. Provide units complete with all required mounting hardware.

Vertical fasteners for backbone (riser) cabling shall be utilize a tension grip support method. Units shall be rated to support vertical runs of

copper and optical fiber cable. Minimum static load unit shall be 11.5 kg 25 pounds.

PART 3 EXECUTION

3.1 INSTALLATION

Installation methods shall be accordance with current edition of the BICSI TDMM, NFPA 70, UL 1479, and EIA ANSI/TIA/EIA-569-A.

3.1.1 Horizontal Segment

3.1.1.1 Raceway and Outlet Box

For each work station outlet, rough-in a 119mm square x 54mm deep4-11/16" square x 2-1/8" deep steel electrical box. Box shall be mounted firmly to the partition stud and provided with a single-gang trim ring mounted vertically to accommodate drywall layering of the partition.

Route a 25mm1 inch conduit concealed up in the partition, and stub out into the ceiling space above the outlet location. Conduit shall be firmly supported and stubbed out in an accessible location.

3.1.1.2 Horizontal Cabling

Horizontal cabling exiting the communications closet or equipment room shall be routed on cable tray or cable hangers, through the ceiling space to the location of the respective station outlet. Bundle cables in groups of 25 or less, and securely fasten to the rungs of the cable tray. Horizontal fiber optic cables shall be routed in innerduct supported on cable tray and cable hangers.

Cable hangers shall be spaced no greater than 1m3 feet on center. Mount to the building structure using approved hardware from the cable hanger manufacturer.

At the conduit stub-out located above the station outlet, neatly coil 1m3 feet of cable and fasten the loop to the cable hanger directly above the outlet drop. Cable shall be routed down the partition in conduit, to the outlet box below.

Cable shall have no physical defects such as cuts, tears, or bulges in the outer jacket. Cables with defects shall be replaced. All cables shall be installed in a neat and workmanlike manner. Neatly bundle and tie all multiple cable runs.

All openings where cable is installed through a fire barrier shall be firestopped, using an approved firestop method and material.

All cables shall be terminated at each end, unless otherwise noted. Provide all labeling at each end of the cable.

3.1.1.3 Customer Faceplates (CFP's)

Install the proper configuration of CFP's as indicated on the drawings. Install all modular jacks and terminators in strict accordance with manufacturer's recommendations.

CFP's shall fit flush to the wall and be plumb and square with wall

surfaces and corners. Any gaps between the plate and the face of the wall shall be neatly filled with a silicone based caulk.

Provide the proper color-coded icons for each type of terminated device, and fill any unused openings with blank inserts. Provide labeling of the CFP and all outlet devices.

3.1.1.4 Remote Distributors

Install remote distributors where indicated on the drawings. Distributors shall be installed so as to be completely accessible, and shall be installed in strict accordance with manufacturer's recommendations. Distributors shall be rated for the location in which it is installed (plenum rated where required).

Properly support the distributor enclosure from the building structure, so as to prevent any sway or sagging. Provide all trim hardware as necessary to complete installation in a neat workmanlike manner, that is integral to the ceiling/adjacent mounting surface.

3.1.2 Backbone Segment

3.1.2.1 Plenum and Riser Rated Optical Fiber Cables

Cable shall be 48/24 (24/12) MM/SM composite (hybrid) fiber optic cable for all connections. All fiber optic cable shall be installed in conduit, cable tray or supported from building structure at 1 m centers. Maintain polarization for entire system as described in EIA ANSI/TIA/EIA-568-A, Section 12.7.1. For optical fiber runs, leave a minimum 3 m service loop at each end, coil and secure.

Adhere to all manufacturer's requirements regarding pulling tension and allowable lubricants. The Contractor shall be responsible for verifying the actual footages and distances identified on the attached prints (i.e. wall-to-wall, pullbox-to-pullbox, etc.). The Contractor shall be responsible for verifying that conduits and raceways are "ready for occupancy" before cable placement. The Contractor shall assume the responsibility for an difficulties or damage to the cable during placement. Where fiber optic cable passes vertically, secure fiber to wall every 1/2 m. Review fasteners, strain relief and routing with Owner, prior to installation. Cables shall be tested and results documented as specified in Section 27 53 13.00 98 TIMING AND COUNTDOWN SYSTEM.

a. Riser and Plenum Rated Innerduct

Adhere to all manufacturer installation guidelines. Pre-lubricate all inner ducts prior to installation. Inner ducts between multiple junction points shall be the same color. Install a 3.2 mm polypropylene pull line, 91 kg pull strength into each unused duct.

b. Optical Fiber Connectors - SM/MM

Connectors shall be installed in accordance with manufacturer's recommendations. Maximum attenuation allowed shall be 0.5 dB per connector.

3.1.2.2 Plenum and Riser Rated Copper Cables

All placement shall conform to industry standards with regard to anchoring, cable support and separation from other facilities. Cables and inner duct shall not sag or droop, but should be installed so as to maintain a flat plane with smooth transitions from one level or direction to another. All cables entering and leaving a splice, as well as the splice itself, shall be appropriately raced to eliminate stress on the cables and/or connections. All cables shall be sufficiently racked and supported in order to eliminate stress on the cable or splice.

a. CMR/CMP Copper Cables

UTP backbone cables may be installed in conduit, cable tray, or in cable hangers 1.8 m on center. Cables above drywall ceilings shall be installed in conduit. Cables in exposed areas other than communications equipment rooms shall be installed in conduit or surface raceway. Cables shall not lay on ceiling or ceiling support structure. They must be anchored in such a way as to not interfere with other services or space access.

Telephone cable ratios shall be two (2) backbone pairs for ever four (4) horizontal pairs. Data cable ratios shall be three (3) backbone pairs for every eight (8) horizontal pairs. Where UTP backbone cable incorporates a campus system (i.e. multiple buildings connected to the backbone), all cable shall be installed with gas tube or solid-state protection devices at both ends of outside cable plant. Cables shall be tested and results documented as specified in Section 27 53 13.00 98 TIMING AND COUNTDOWN SYSTEM.

b. ARMM Copper Cables

Secure all ARMM cables to wall within 12" of all splice enclosures. UTP backbone cables may be installed in conduit, cable tray, or in cable hangers 1.8 m on center. Cables above drywall ceilings shall be installed in conduit. Cables in exposed areas other than communications equipment rooms shall be installed in conduit or surface raceway. Cables shall not be allowed to lay on ceiling support structure. They must be anchored in such a way as to not interfere with other services or space access. Where UTP backbone cable incorporates a campus system (i.e. multiple buildings connected to the backbone), all cable shall be installed with gas tube or solid-state protection devices at both ends of the outside cable plant. Cables shall be tested and results documented as specified in Section 27 53 13.00 98 TIMING AND COUNTDOWN SYSTEM.

c. Vault and Riser Closures

In vault environment or other horizontally configured installations, support splice closure at both ends via racks and steps. Secure riser closures to wall with heavy-duty cable ties.

d. Splicing

Fold back method of splicing is required for all new splices. Ends of unused binder groups shall be staggered, cleared and encapsulated with appropriate capping kits. Terminal counts shall

be installed as per the drawings and may not be split or multiplied.

Binder group and color code integrity shall be maintained. Striped nylon cable ties shall be used to identify binder groups on both sides of the splices and at all other sheath openings.

The quantity of bad pairs per sheath of 100 pairs or more shall not exceed 1 percent of the total pair count. All cable pairs shall be free of electrical opens, shorts (within and between pairs), polarity reversals, transpositions, and the presence of AC voltage, from the Communication Equipment Room to the termination hardware at the main cross-connect frame. All defects must be corrected. Tape all entries to vault and riser closures to prevent water, insects or rodents from entering closures. Install bonding connectors so as not to damage the conductors in the cable.

3.2 ADDITIONAL MATERIALS (SPARE PARTS)

The Contractor shall provide and deliver the following additional materials to the COTR at the completion of the project:

a. An amount equal to 5% of the total number of connectors installed, for each type of connector.

b. An amount equal to 5% of the total number of modular jacks installed, for each type of jack.

c. An amount equal to 5% of the total number of CFP's installed, for each type of CFP.

d. An amount equal to 5% of the total number of patch cords installed, for each color, length, and type of patch cord.

e. One set of any and all "special" tools required for hardware or equipment provided under this contract.

3.3 LABELING

All labeling shall be in accordance with KSC-STD-E-0021, and the following:

a. Each jack shall be labeled at the faceplates as indicated on the As-Built drawings submitted by the Contractor.

b. All wires shall be labeled at all termination points.

c. All patch panels in closets and remote distributors shall be labeled as indicated on the As-Built drawings.

3.4 CABLE SCHEDULES

The Contractor shall compile cable schedules for all telephone and computer network (data) cables. Schedules shall be in accordance with KSC Standard KSC-STD-E-0021. Schedules shall serve as input data for the user's/support contractor's cable management system, and shall be submitted in accordance with paragraph 1.4 (SD-07), of this section. It shall be the Contractor's responsibility to coordinate with the Contracting Officer to confirm the electronic file format in which the schedules must be submitted.

3.5 TESTING

For Category 5E and fiber optic cable testing, Level II or higher instruments are required.

Provide all adapters, cords, optional modules, etc., to perform all required tests. Calibration procedures shall be in strict accordance with manufacturer's recommendations.

3.6 COPPER PAIR TESTING

Category 5E cables and connecting hardware shall be tested to confirm transmission parameters characterized up to 100 MHz in accordance with EIA ANSI/TIA/EIA-TSB-67.

The following parameters shall be investigated by the testing process:

a. Characteristic Impedance - Input impedance of the cable.

b. Wire Map (Continuity) - Copper continuity shall be tested using a resistance measurement. Fiber continuity shall be tested using a visible light source.

c. Installed Length - Length is 100m328 feet for the "channel" plus 10 percent. The pair with the shortest electrical delay shall be used for the maximum length calculation.

d. Attenuation - Attenuation shall be the sum of the contribution from all components. The total attenuation shall be greater than dB to constitute an accurate test.

e. Near End Crosstalk (NEXT) - NEXT shall be the sum of the contribution of the cable and only near end connectors (2 connectors per channel). NEXT must be tested from both ends of cable.

f. Return Loss - Measurement shall indicate the amount of power in dB, reflected from the cabling. A consistent frequency range shall be used throughout testing.

g. Equal Level Far End Crosstalk (ELFEXT) - ELFEXT shall be the ratio of the attenuated signal on one pair to the crosstalk on an adjacent pair at the far end.

h. Propagation Delay/Delay Skew - Propagation delay shall be the time required for a signal to travel down a cable. Delay skew shall be the difference in the propagation delay between any pairs within the same cable.

i. Attenuation to Crosstalk Ratio (ACR) - ACR shall be calculated as follows:

   ACR = NEXT Loss - Attenuation Loss

   ACR shall be calculated at the characteristic frequency (CAT 5E = 100 MHz).

3.6.1 Backbone Cabling

The following parameters shall be tested on all backbone cabling.

a. Wiremap

b. Installed length

c. Attenuation

d. NEXT

1. For 25-pair cabling, provide "power sum" NEXT.

3.6.2 Horizontal Cabling

All horizontal UTP cabling shall be tested using the "channel" configuration. The following tests shall be performed.

3.6.2.1 Category 5E

Testing shall utilize a 4-connector channel model and worst case value of testing parameters. The following parameters shall be tested for Category 5E horizontal cabling:

a. Continuity

b. Installed length

c. Attenuation

d. NEXT (Pair-to-Pair and Power Sum)

e. Characteristic (input) impedance

f. Return Loss

g. ELFEXT (Pair-to-Pair and Power Sum)

h Propagation Delay/Delay Skew

i. ACR

3.7 OPTICAL FIBER CABLE TESTING

Optical fiber testing shall be in accordance with EIA ANSI/TIA/EIA-TSB-455

Optical fiber cable testing shall be performed to determine end-to-end attenuation of the cable. The attenuation shall be the optical power loss in dB.

The following test wavelengths shall be utilized for the indicated type of cable:

a. 850 nm/1300 nm for multimode fiber
b. 1310 nm/1550 nm for single-mode fiber

Optical Time Domain Reflectometer (OTDR) testing shall be provided on all backbone cabling. Where OTDR testing is required, test in both directions

and take the average.

3.7.1 Testing Guidelines

The following guidelines shall be followed when performing testing on optical fiber cable:

a. Test jumpers shall be of the same fiber core size and connector type as the cable system.

b. The power meter and the light source shall be set to the same testing wavelength.

c. Power meter must be calibrated and traceable to the National Institute of Standards and Technology.

d. The light source or OTDR must operate within the range of 850 +/- 30 nm or 1300 +/- 20 nm for multimode testing. The light source or OTDR must operate within the range of 1310 +/- 10 nm or 1550 +/- 20 nm for single-mode testing.

e. All system connectors, adapters, and jumpers shall be properly cleaned, prior to taking measurements.

3.7.2 Backbone Cabling

Multimode fibers in backbone cabling structures shall be tested at both 850 nm and 1300 nm. Single-mode fibers in backbone cable structures shall be tested at both 1310 nm and 1550 nm. Provide an OTDR signature trace for all backbone cabling. Recorded data for maximum attenuation shall be compared with manufacturer's published data.

3.7.3 Horizontal Cabling

Multimode fibers shall be tested at either 850 nm or 1300 nm for all horizontal channels. Single-mode fibers used in a horizontal application shall be tested at both 1310 nm and 1550 nm.

Any fibers left unterminated in the horizontal segment, shall be tested with an OTDR to confirm attenuation of the link cable.

3.8 FIBER OPTIC CABLE MANUFACTURER TEST DATA

3.8.1 Test Data and Physical Parameters

The cable manufacturer has the responsibility to provide the Contracting Officer test data and physical parameters of the following items as supplied to him by the fiber manufacturer:

3.8.1.1 Test Data

Attenuation for each SM and MM fiber.

Bandwidth for each MM fiber.

3.8.1.2 Physical Parameters

Chromatic dispersion for SM and MM fiber.

Effective group index of refraction at 1300 nm of SM and MM fiber.

Cut-off wavelength of SM fiber.

Mode field diameter of SM fiber.

Numerical aperture of MM fiber.

Cladding diameter of SM and MM fiber.

Core-cladding offset of SM and MM fiber.

Primary protective coating diameter of SM and MM fiber.

Tensile strength of SM and MM fiber.

3.8.2 Test Data of Completed Optical Cable

3.8.2.1 Optical Performance Data

The cable manufacturer shall test each reel of completed cable for the following parameters:

Attenuation of each SM and MM fiber in the completed cable (reeled) length.

Bandwidth of each MM fiber in the completed cable (reeled) length.

Cut-off wavelength of six SM fibers in a tested sample.

3.8.2.2 Temperature Testing Data

The cable manufacturer shall test a 500 meter1641 feet or longer length of cable taken from a representative sample of cable for optical attenuation as stated in Paragraph 7.2, Temperature Cycling Added Loop Test, and Paragraph 7.3, Temperature Aging.

3.8.2.3 Mechanical Performance Data

The cable manufacturer will certify that the cable will meet the following mechanical properties as verified by test samples:

Cable minimum bend radius

Cable tensile strength

Flexing or bending cycles

Crush resistance

Impact resistance

Gel filling compound drip

Fluid penetration

3.8.3 Government Approval

Test procedure test methods, and test data for the tests performed by the

fiber manufacturer shall be provided to the Contracting Officer when fiber is delivered to the cable manufacturer. The test procedure for the finished cable identifying the test methods, including test equipment with block diagrams, and test data sheets shall be provided to the Contracting Officer for review and approval 30 days prior to test start. Test data results on the finished cable shall be provided to the Contracting Officer for review, and shipment shall not be made until Government approval has been provided.

-- End of Section --